Element-Resolved Spin Configuration in Manganese-Doped GaAs and Atomic Origins of Magnetic Hardness in NdFeB*

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In the first part of the talk, we report measurements of the GaAs host polarization using soft x-ray magnetic circular dichroism (XMCD) at the Mn, Ga and As L edges. We find that As moments are antiparallel to the Mn and that Ga are parallel, but very small. These results are consistent with the notion that polarized As valence band holes mediate the ferromagnetic coupling between Mn ions in $Ga_{1-x}Mn_xAs$.

In the second part, we discuss the atomic origin of magnetic hardness in our best permanent magnet – $Nd_2Fe_{14}B$. Rare-earth (RE) ions dramatically enhance magnetic stability through the interaction of their anisotropic (4f) electron clouds with the electric field of surrounding charges. Here we show that the *simultaneous* presence of RE ions in dissimilar atomic environments undermines the intrinsic stability of the highest performance permanent magnets. Experiments were done by using helicity-dependent resonant diffraction technique in combination with a digital lock-in detection scheme that synchronizes the measured x-ray diffracted intensity with the helicity modulation of the incoming x-ray beam. Our results show that unequal neodymium sites in the unit cell of a neodymium-iron-boron single crystal prefer local magnetic moment orientations orthogonal to one another, reducing magnetic stability. These findings highlight the need for manipulating the local atomic structure around rare-earth ions for complete optimization of future magnets.

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